Pump
frequency
f^p

$$f_{out} = f^p$$

Figure 1

Pump
frequency
f^p

$$f_{out} = f^p - f_{in}$$

Difference-frequency generation

Figure 2

304

302

Pump
frequency
f^p_1

Pump
frequency
f^p_2

300

301 f_{in}

Wave
Mixer
DFG

$f^1_{out} =$
$f^p_1 - f_{in}$
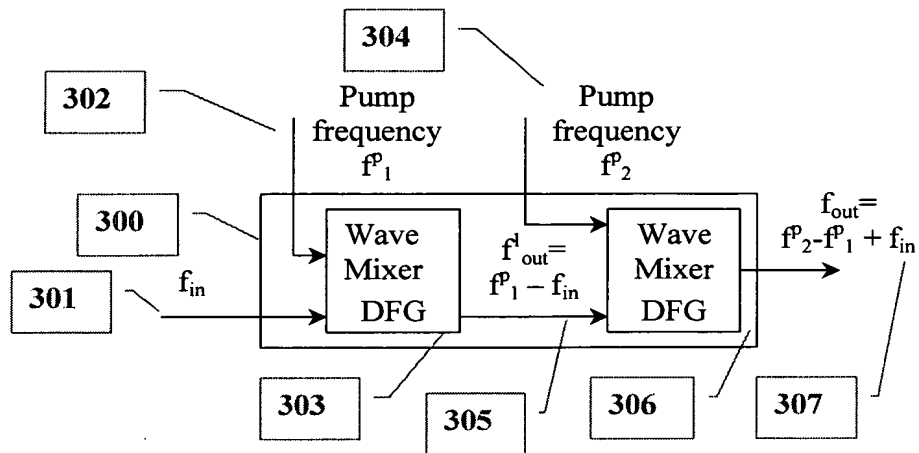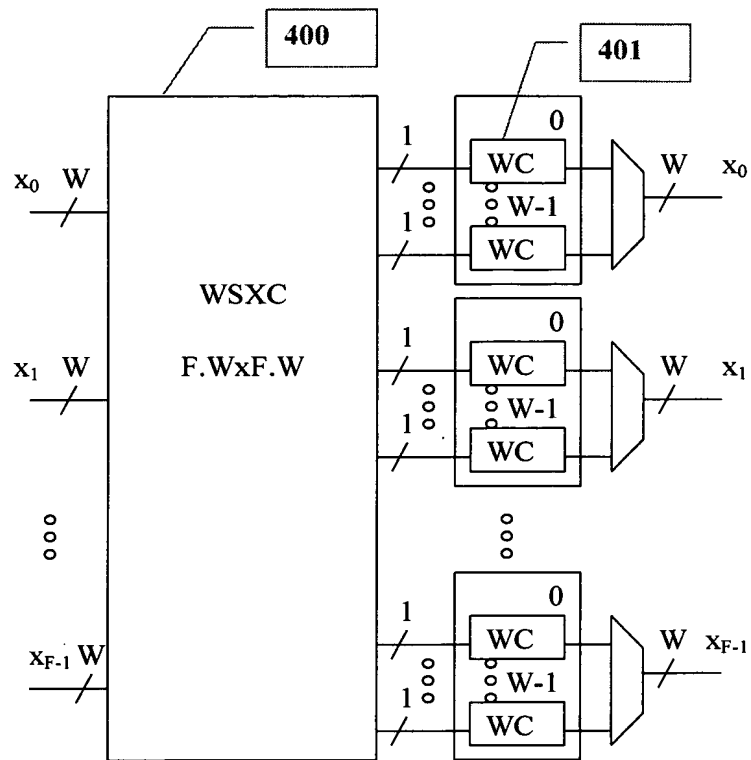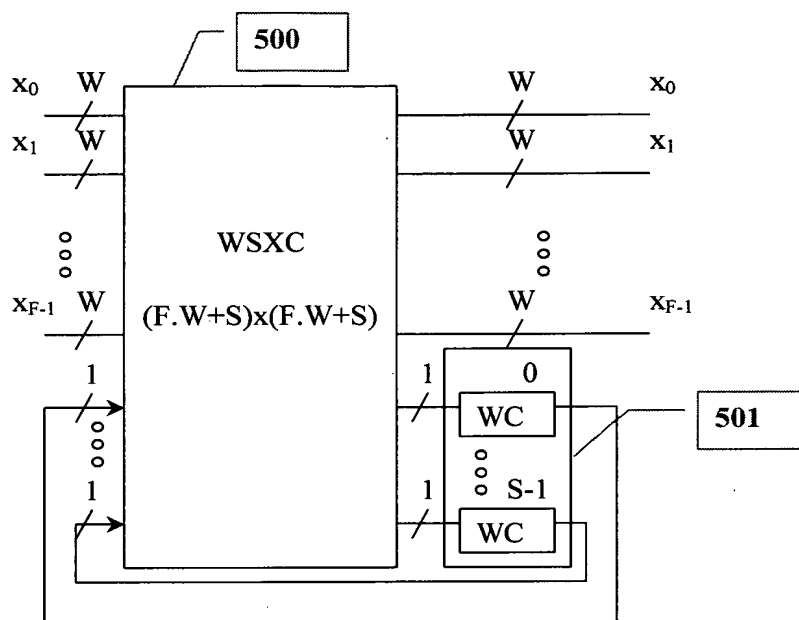
Wave
Mixer
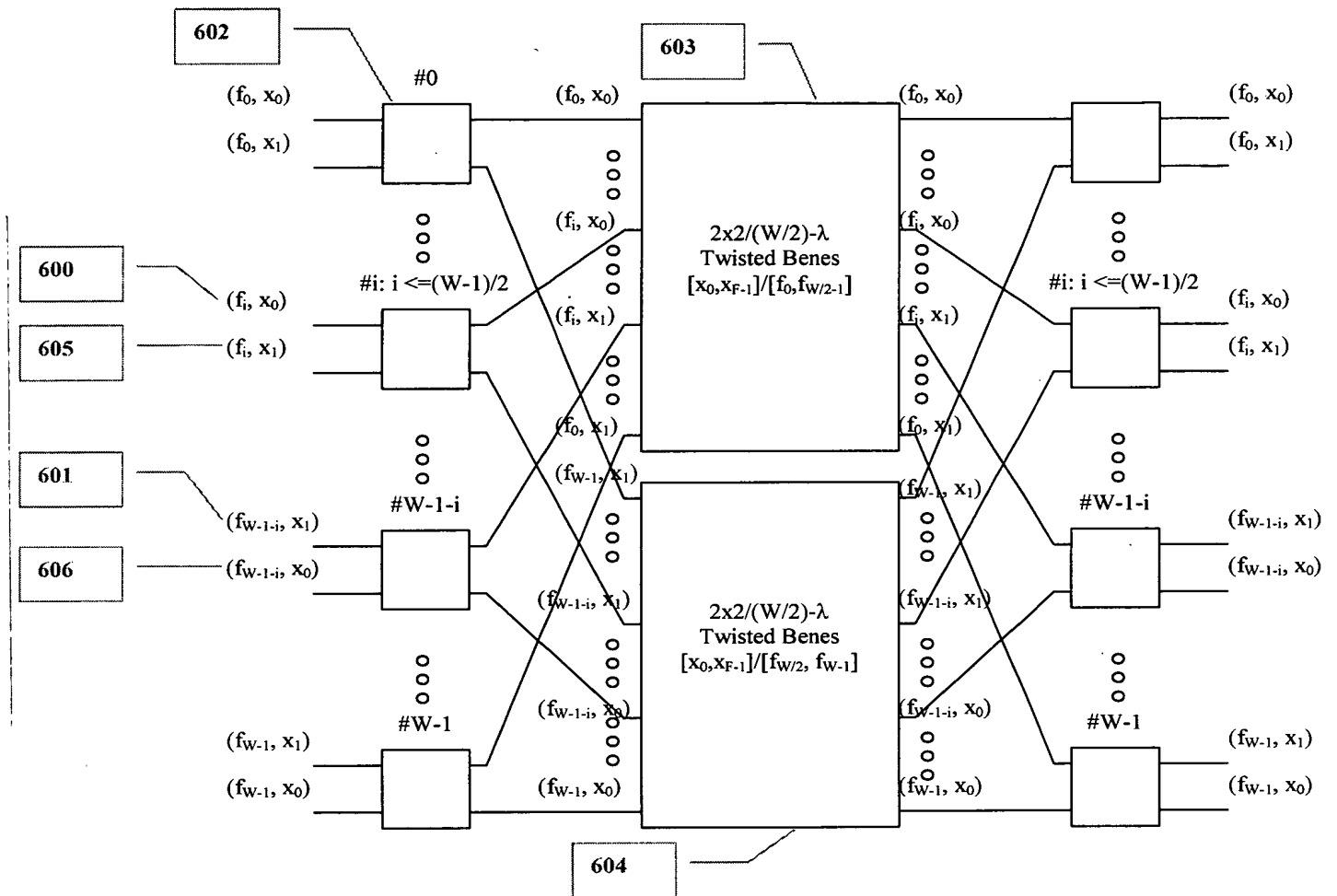DFG

$f_{out} =$
$f^p_2 - f^p_1 + f_{in}$

303 305 306 307

Figure 3

Figure 4

Figure 5

Figure 6
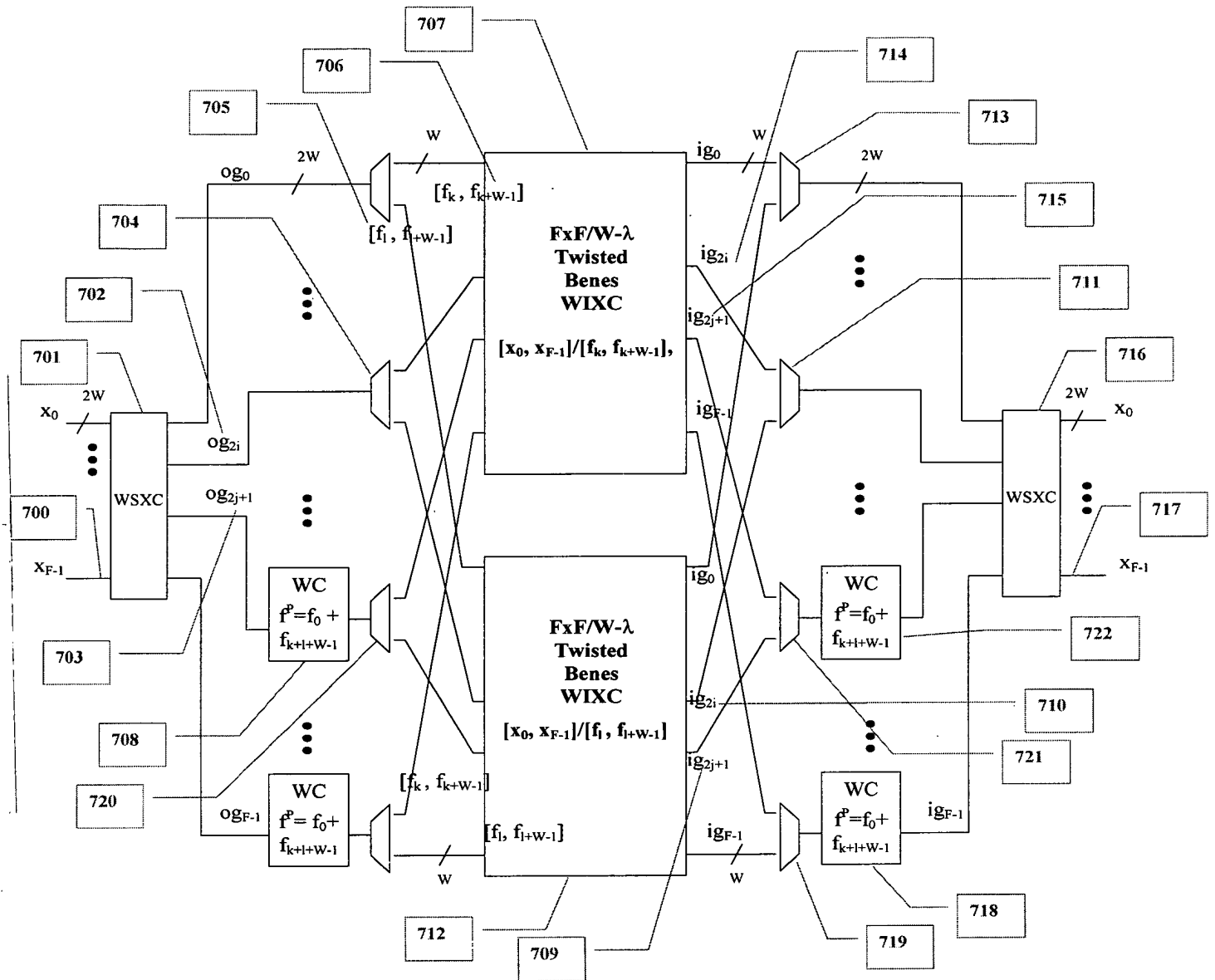
Figure 7
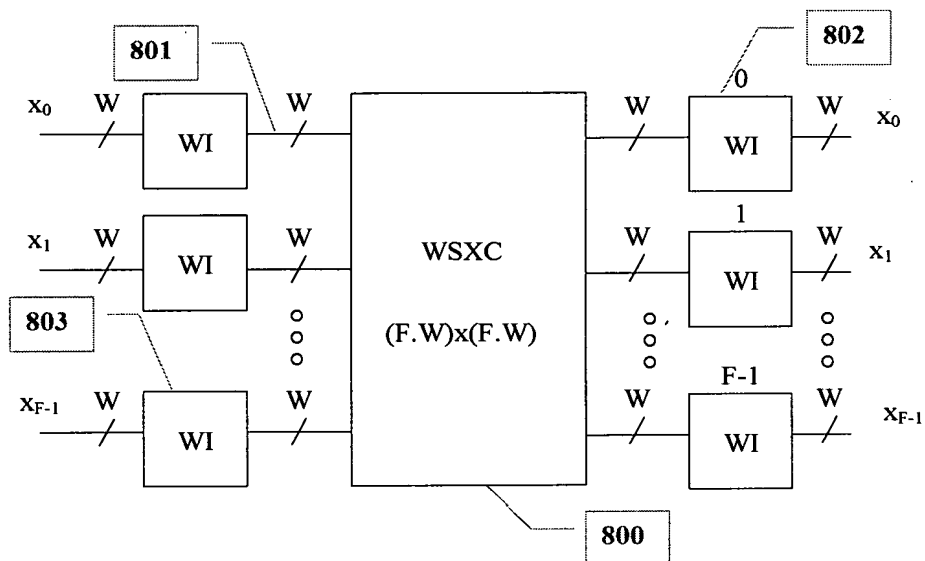
Figure 8
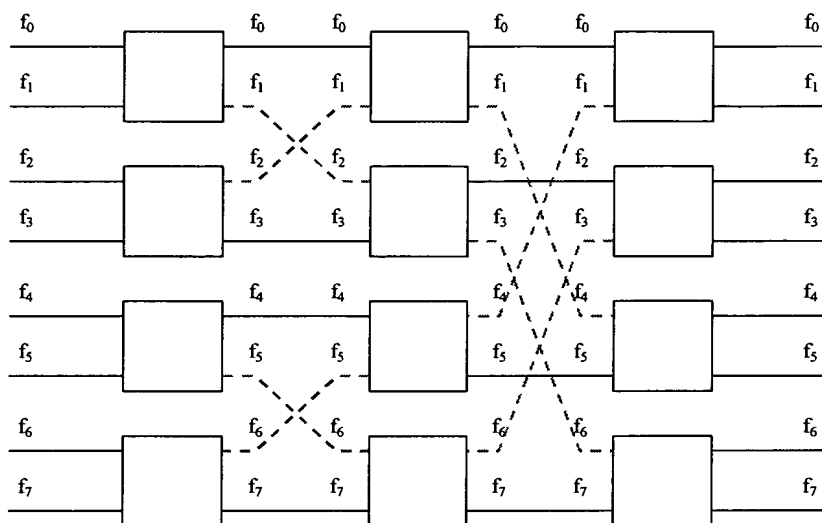
Figure 9

Log$_2$(8,1,1) network

Original self-routing network   One horizontal extension

Log$_2$(8,2,1) network

Original self-routing network   Two horizontal extensions
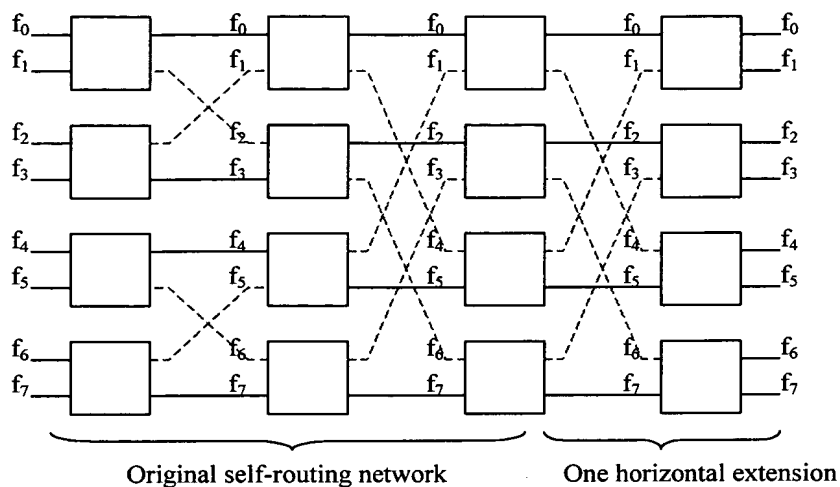
Figure 10

Figure 11

Figure 12

Figure 13

f_i
signal i　　　　　　　　f_i
signal i

SE

f_{i+1}
signal i+1　　　　　　f_{i+1}
signal i+1

Bar state

f_i
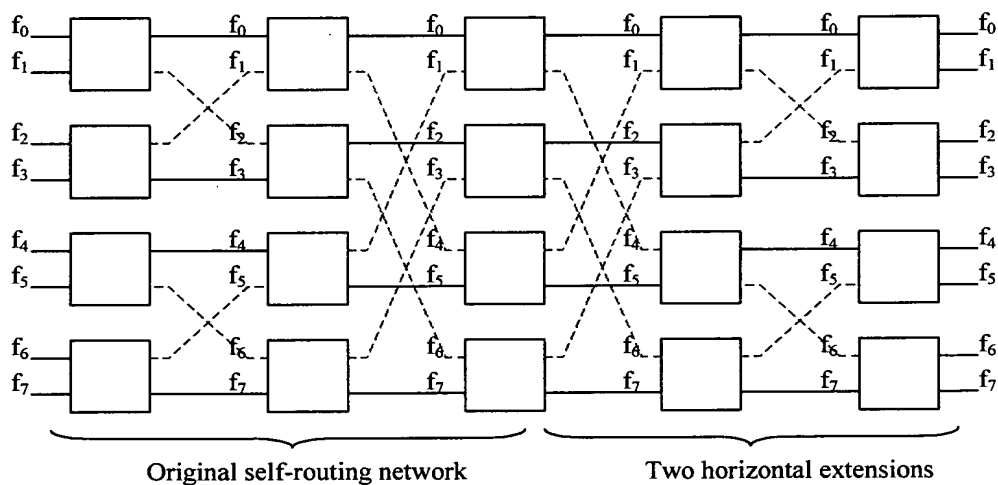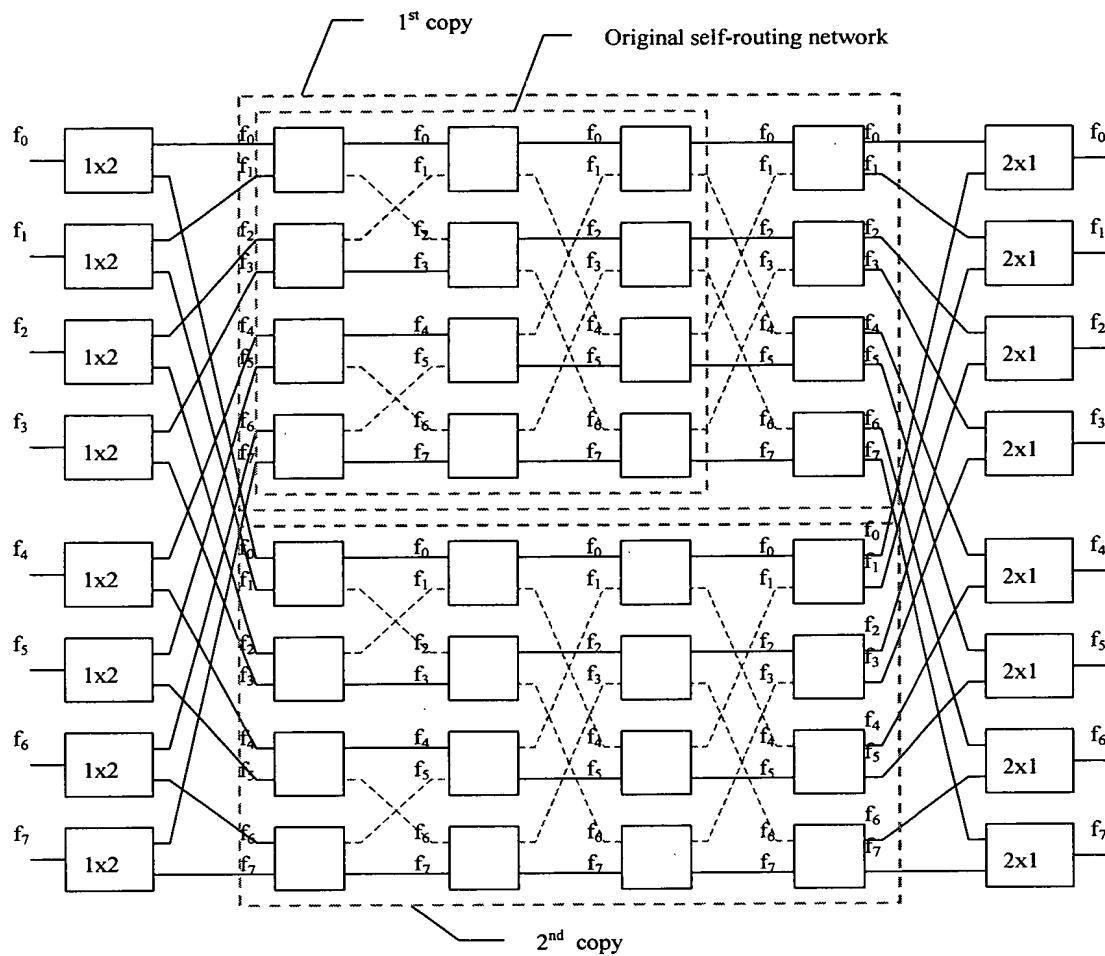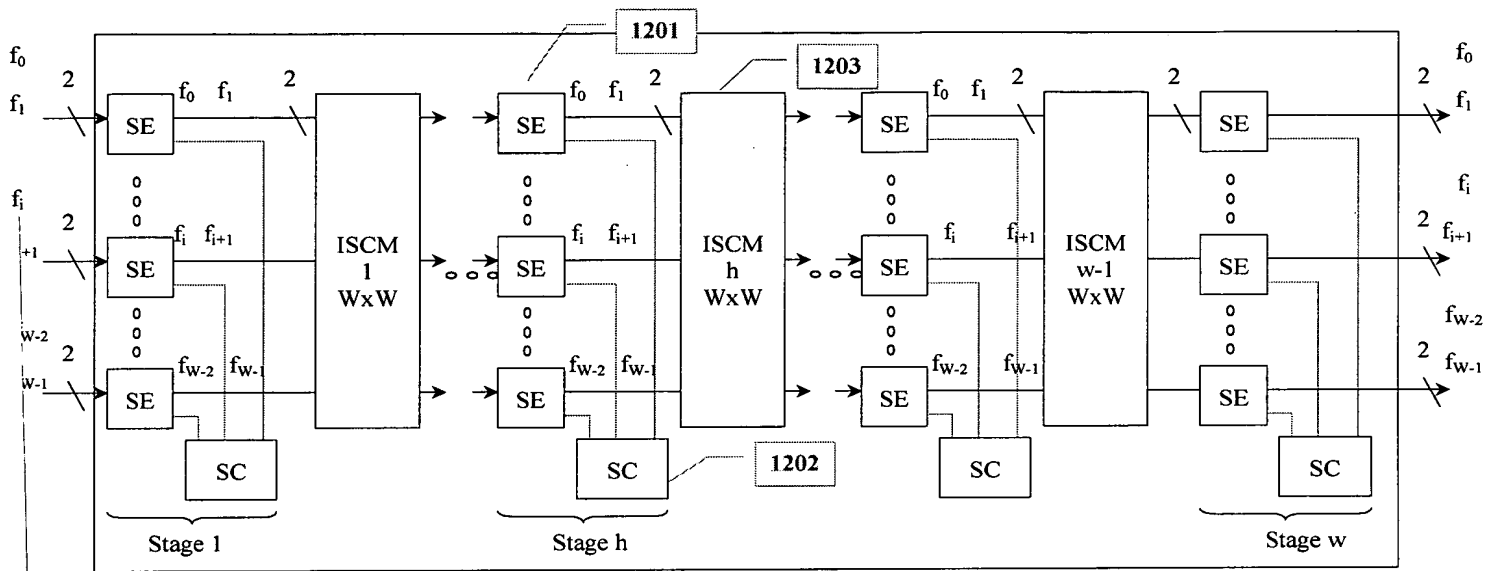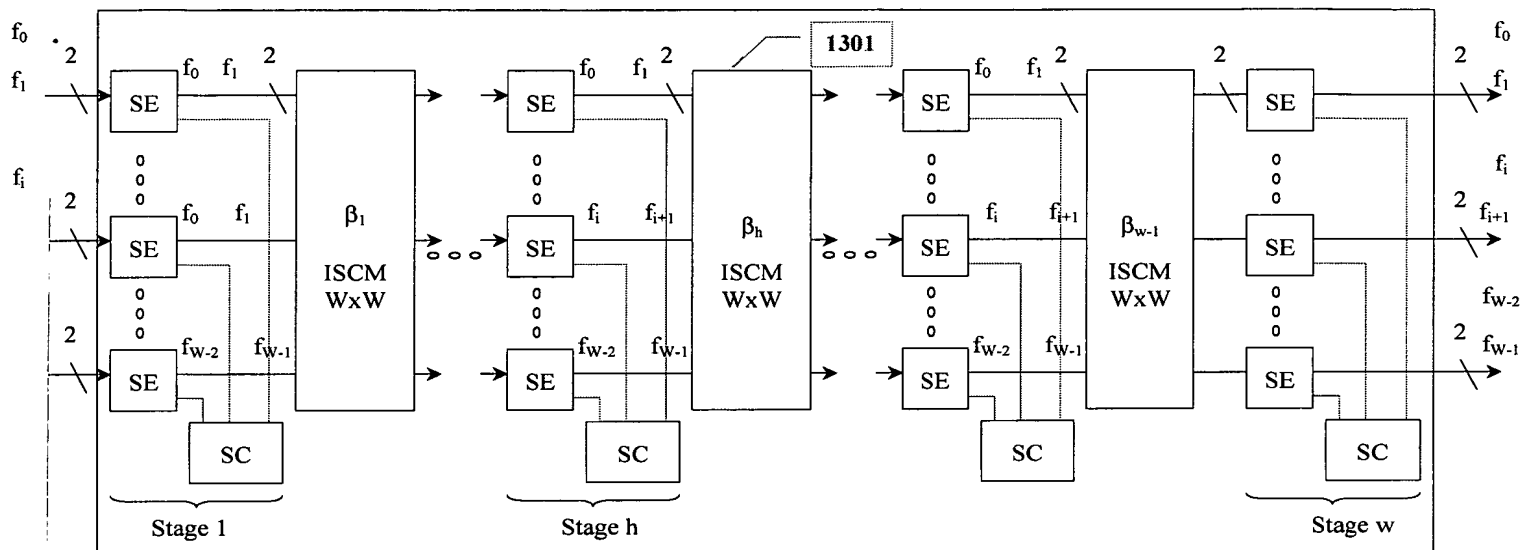signal i　　　　　　　　f_i
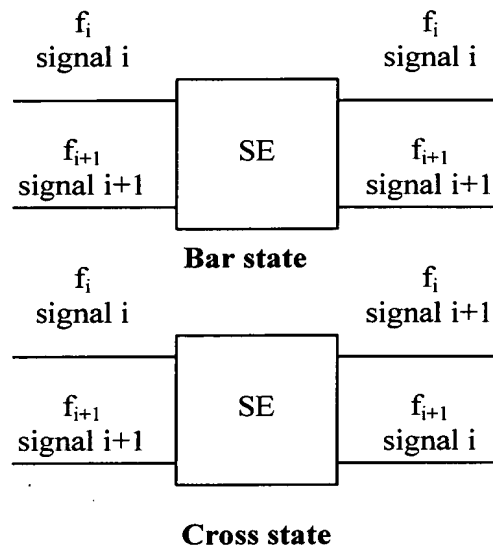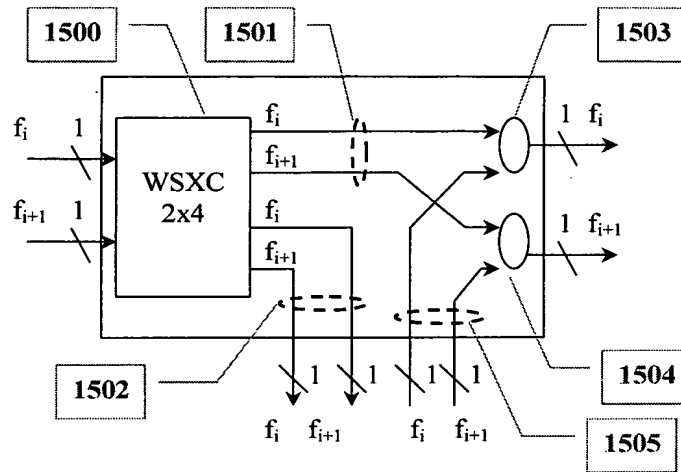signal i+1

SE

f_{i+1}
signal i+1　　　　　　f_{i+1}
signal i

Cross state

Figure 14

Figure 15

Figure 16

Figure 17

Figure 18

1902

1901

1903

1907

1906

1905

1904

f_0 1

f_1 1

| Wavelength router WxW | W/2 | Frequency shifter $-\Delta f$ | W/2 | Increasing down-converter | W/2 | Frequency shifter $+2^h.\Delta f$ | W/2 | Wavelength router WxW |

1 f_0

1 f_1
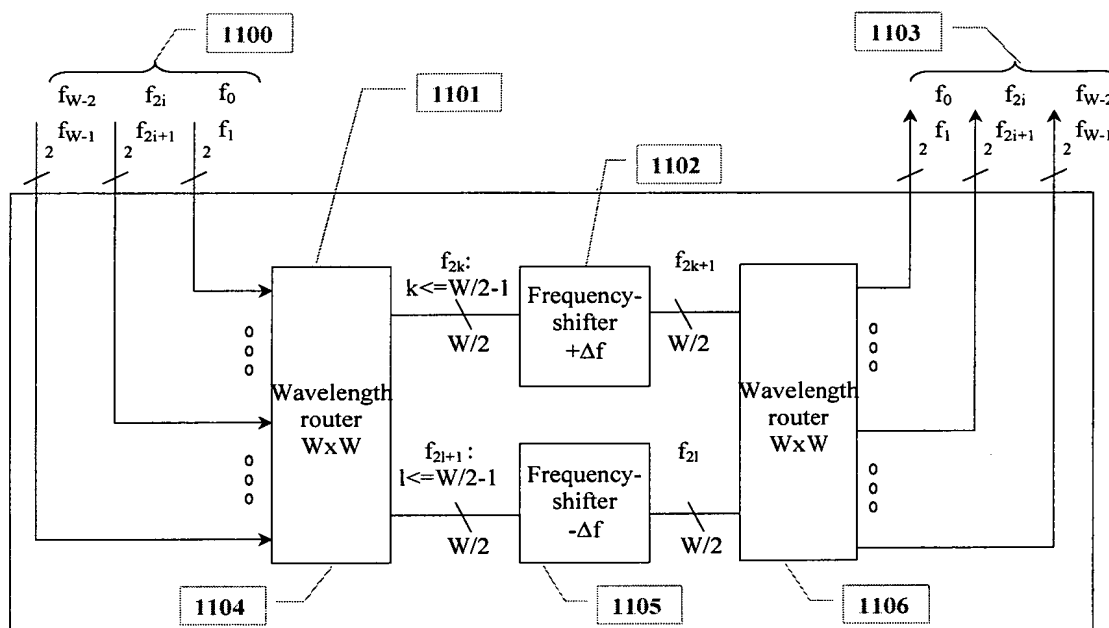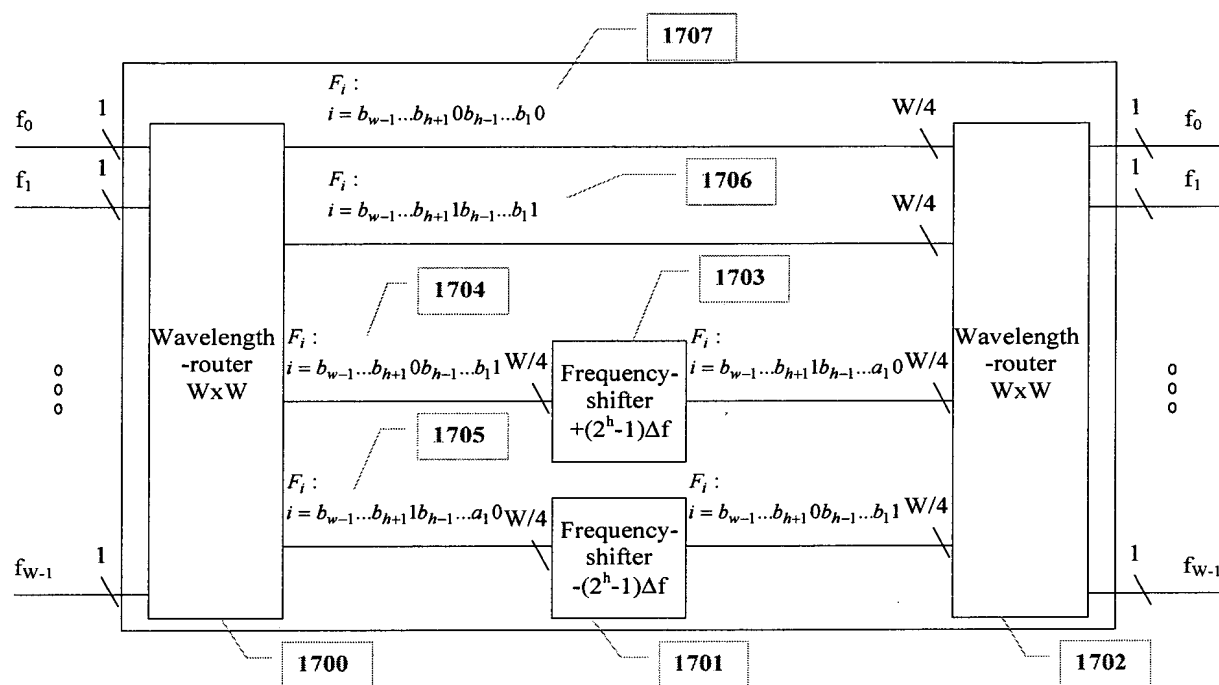
f_{W-1} 1

W/2   Increasing down-converter   W/2

1 f_{W-1}

1900

1908

1909

1910
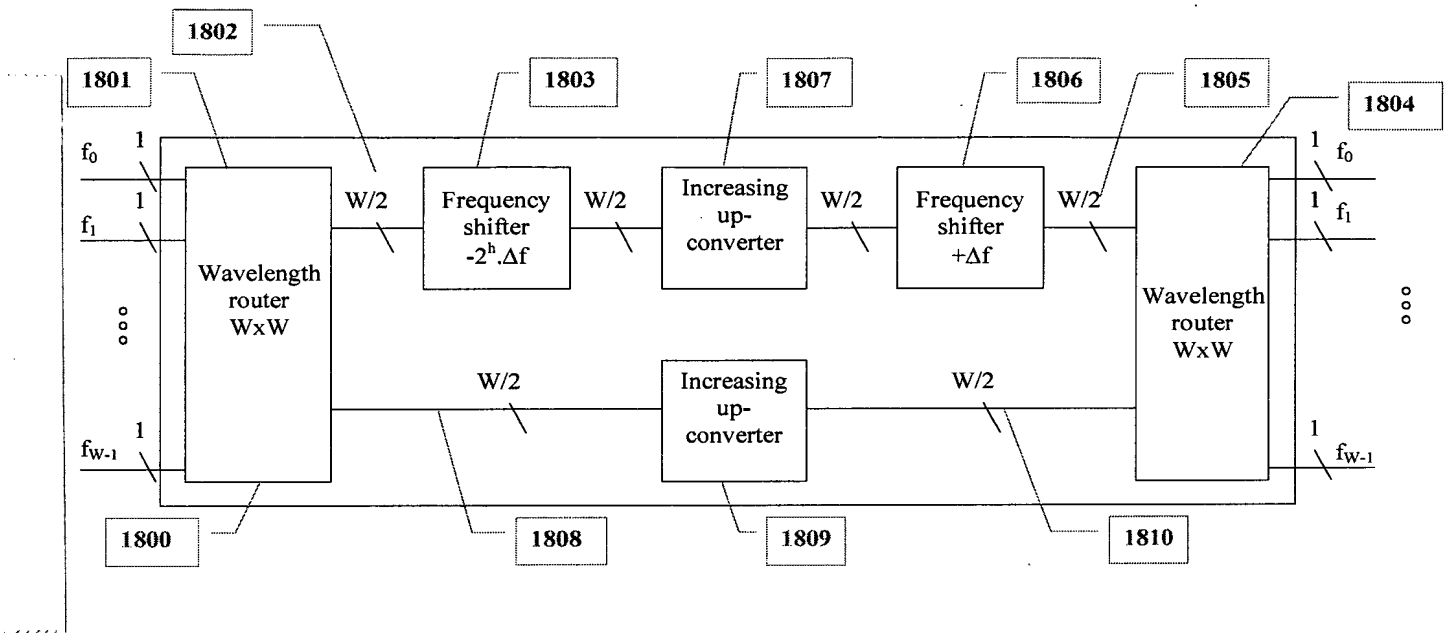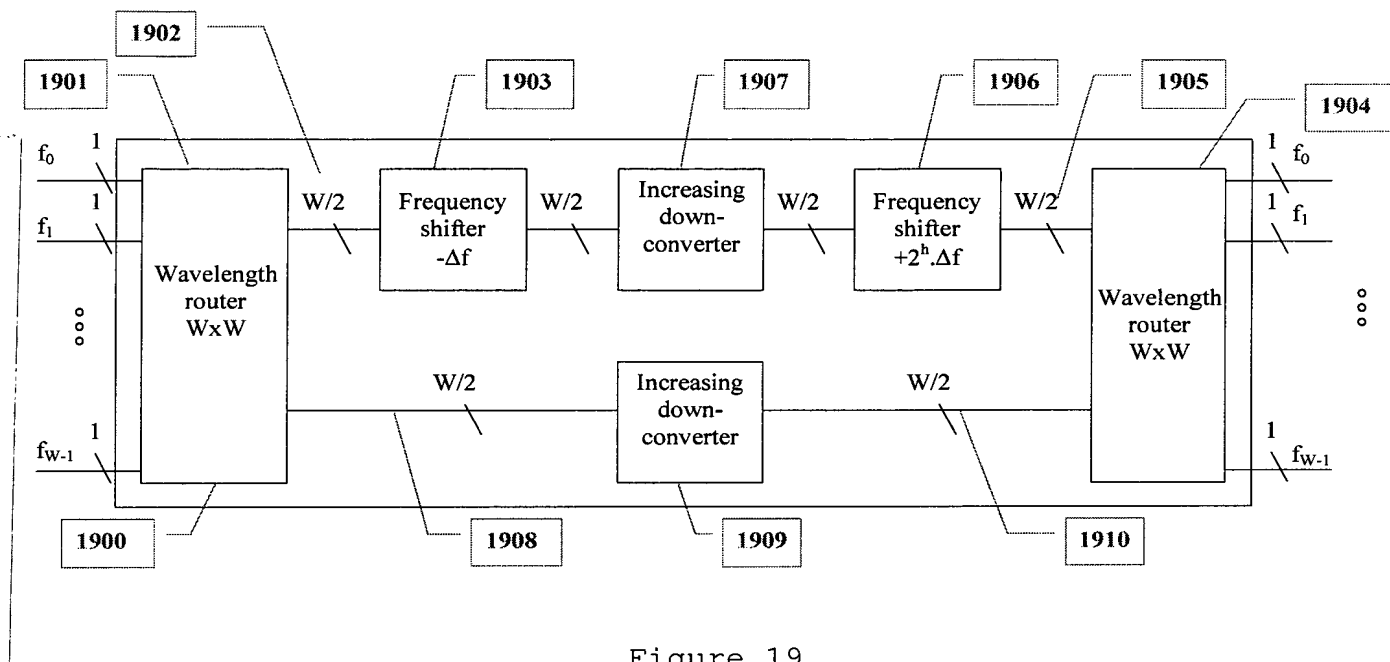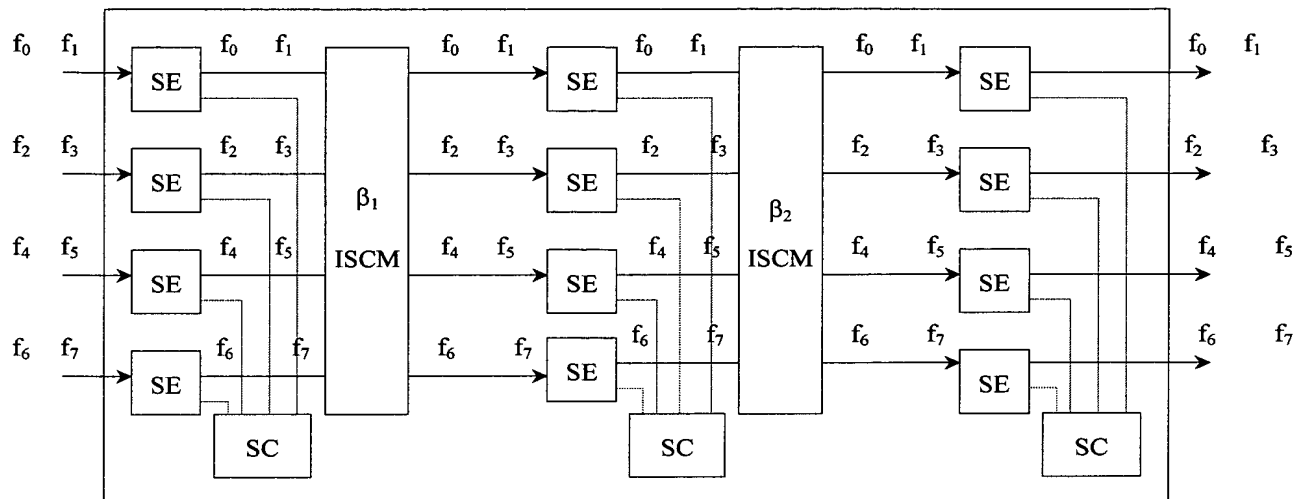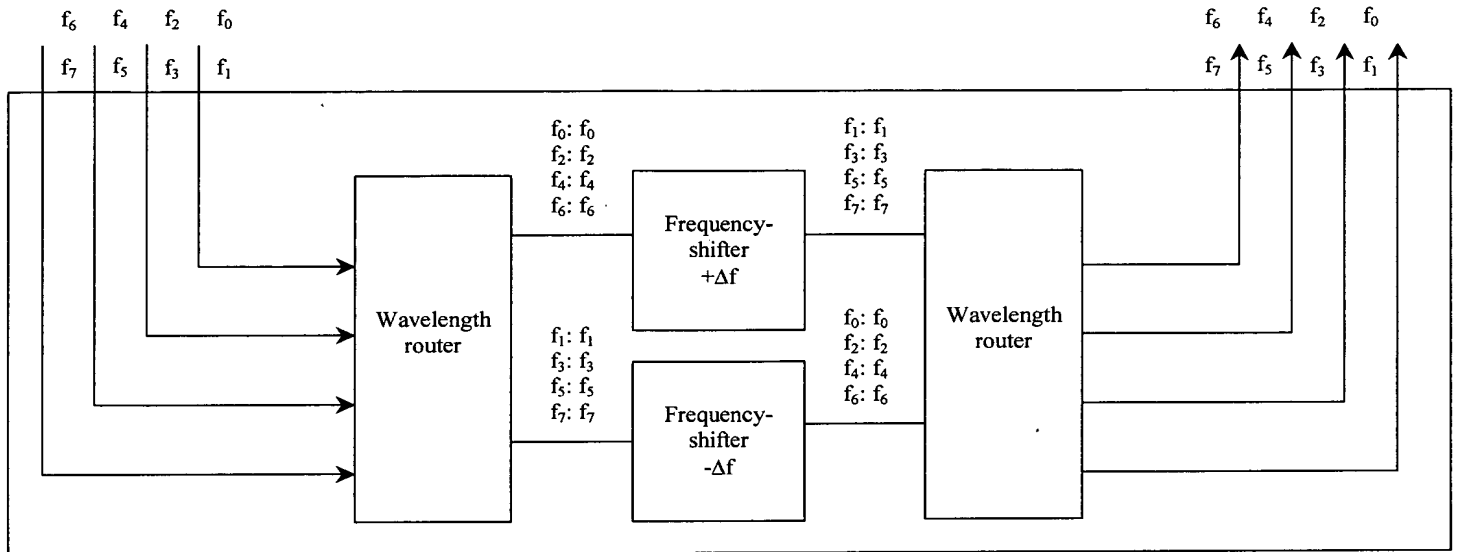
Figure 19

Figure 20

Figure 21
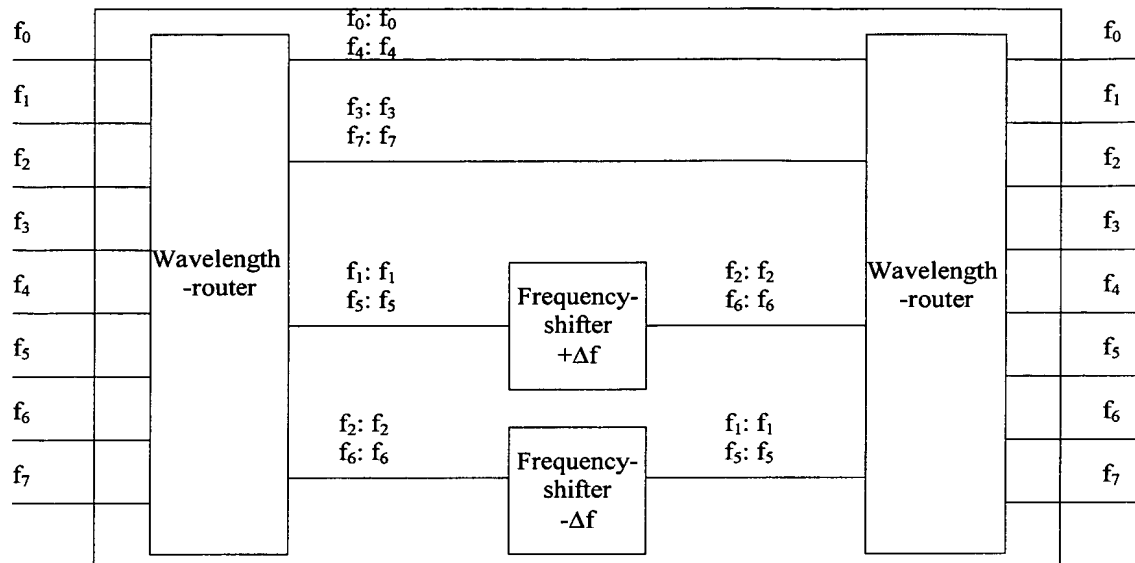
Figure 22
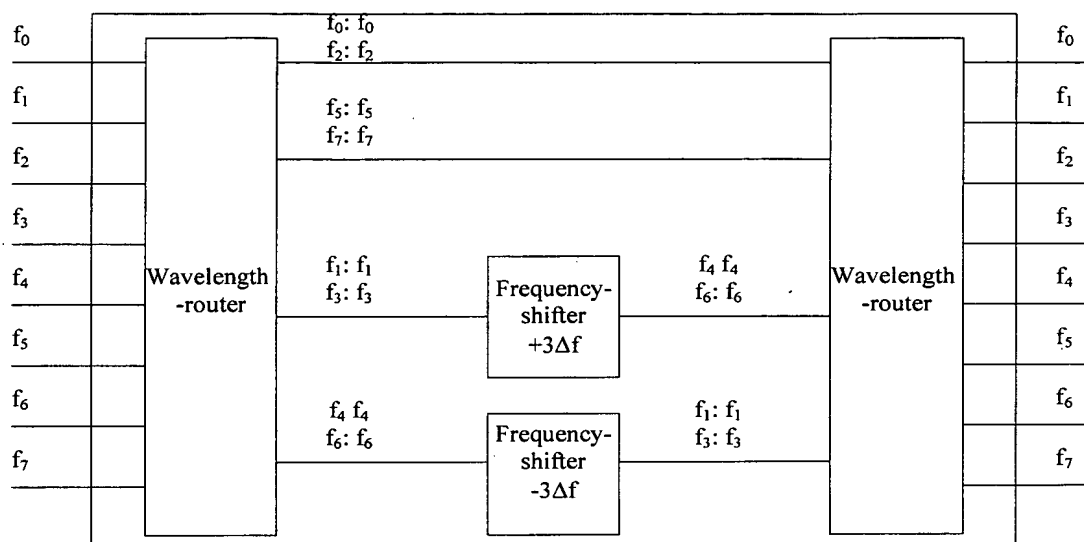
Figure 23
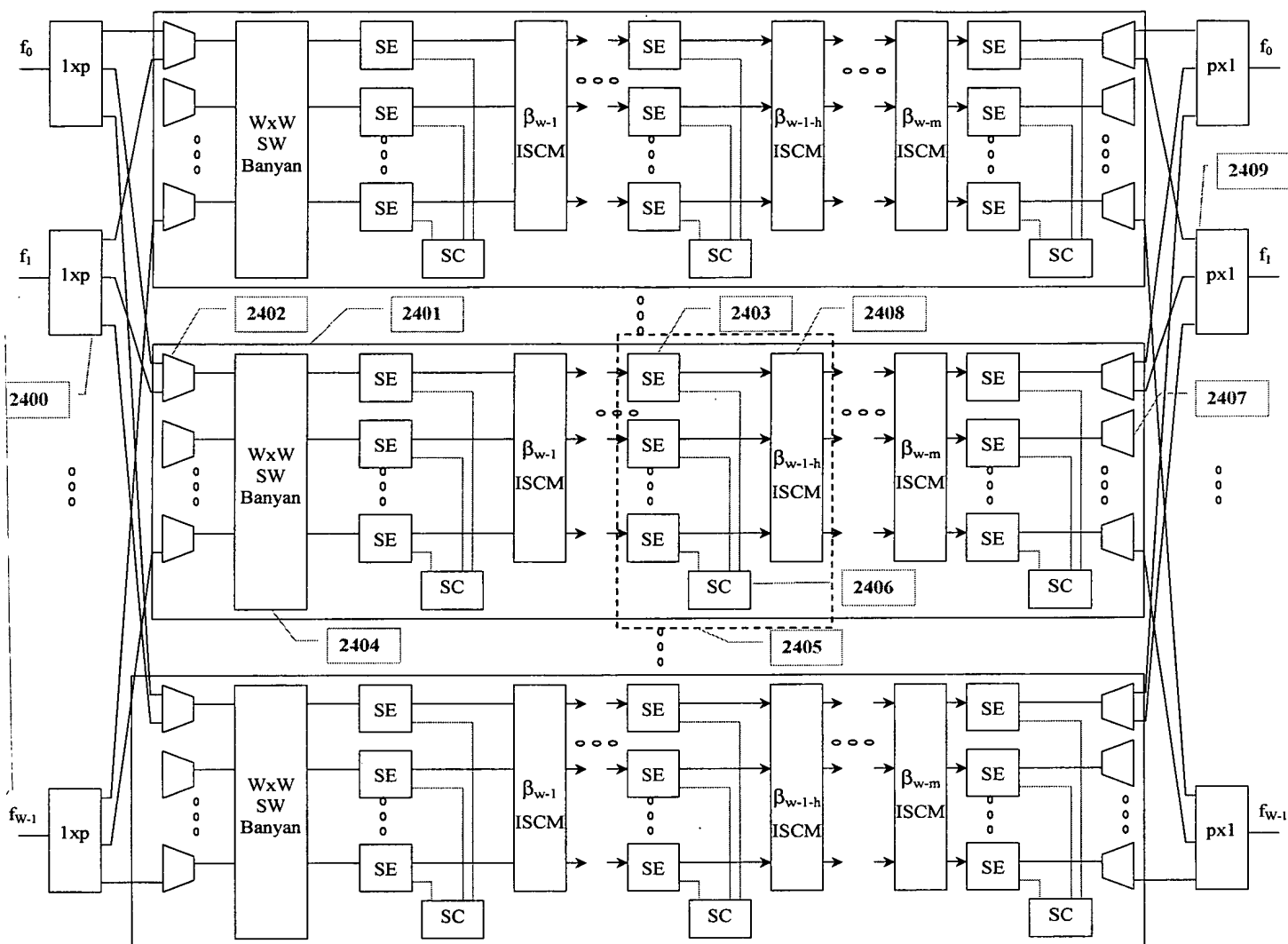
Figure 24

	P(0)	P(h) $0<h<n$	P(n)
Omega	σ_{n-1}	σ_{n-1}	J
Omega^{-1}	J	σ_{n-1}^{-1}	σ_{n-1}^{-1}
SW-Banyan	J	β_h	J
SW-Banyan^{-1}	J	β_{n-h}	J
n-cube	σ_{n-1}	β_{n-h}	J
n-cube^{-1}	J	β_h	σ_{n-1}^{-1}
Baseline	J	σ_{n-h}^{-1}	J
Baseline -1	J	σ_h	J

Figure 25

Component	Number	Frequency-shifters
State changer	$\log_2(W)$	2
Butterfly ISCM	$\log_2(W)-1$	2

Figure 26

Self-routing network	Number of frequency-shifters
SW-Banyan	$O(\log_2 W)$
Baseline	$O\left((\log_2 W)^2\right)$
n-cube	$O(\log_2 W)$
Omega	$O\left((\log_2 W)^2\right)$

Figure 27

Networks	Near-optimal parameter choice	Wavelength-interchanger frequency-shifter complexity	Overall separable cross-connect frequency-shifter complexity
Near-optimal rearrangeably nonblocking	$m = w - 1$ $p = 1$	$4w - 4$	$4.F.(w-1)$
Near-optimal strictly-nonblocking	$m = w - 1$ $p = w$	$4.w^2 - 4.w$	$4.F.w.(w-1)$

Figure 28